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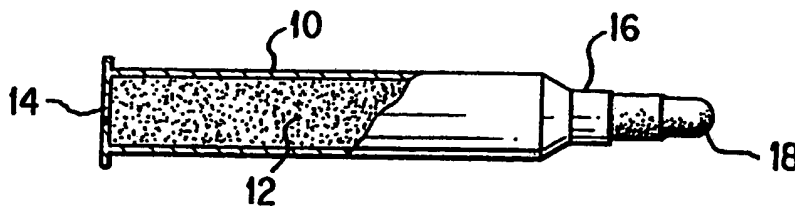
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Published

*With international search report.**With amended claims and statement.*

(54) Title: LEAD-FREE FIREARM BULLETS AND CARTRIDGES INCLUDING SAME



## (57) Abstract

A firearm bullet, at least a major portion of which is formed of a one-piece element having a continuous all-metal structure primarily made up of bismuth or a bismuth alloy.

# + DESIGNATIONS OF "SU"

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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LEAD-FREE FIREARM BULLETS  
AND CARTRIDGES INCLUDING SAME

BACKGROUND OF THE INVENTION

Field of the Invention

5       The present invention relates to improved bullets for firearms, and cartridges including same.

Description of the Background Art

10       Most bullets for firearms are formed totally or partially from lead. The density of lead provides bullets made therefrom with a ballistic efficiency which heretofore has not been matched by any other commercially available bullet material. While bullets jacketed with an outer layer of copper or other material are available to prevent barrel fouling and the like, such bullet cores typically are made of lead  
15       to provide the bullet with acceptable ballistic properties. Unfortunately, lead is quite toxic, which has raised environmental concerns.

20       Lead core bullets which are clad in copper or other material do not eliminate the toxicity problem, since the copper sheathing typically peels back when a fired bullet impacts an object, thereby exposing the lead core.

25       There remains a need in the art for completely lead-free bullets which perform ballistically similar to bullets made with lead.

### SUMMARY OF THE INVENTION

In accordance with one aspect of the present invention, a projectile is provided which comprises a firearm bullet, at least a principal portion of which is formed of a one-piece element having a continuous all-metal structure primarily made up of bismuth.

In accordance with another aspect of the invention, a firearm cartridge is provided comprising a casing, a propellant contained within the casing, means for igniting the propellant, and a firearm bullet, at least a principal portion of which is formed of a one-piece element having a continuous all-metal structure containing bismuth.

### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partly schematic cross-sectional view of a firearm cartridge including a one-piece bullet containing bismuth according to one embodiment of the present invention.

Fig. 2 is a partly schematic cross-sectional view of a one-piece, bismuth-containing shotgun slug according to another embodiment.

Fig. 3 is a partly schematic cross-sectional view of a two piece, bismuth-containing bullet according to still another embodiment.

Fig. 4 is a partly schematic cross-sectional view of a three piece, bismuth-containing bullet according to yet another embodiment.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 illustrates a firearm cartridge including a casing 10 which can, for example, be made up of brass. Within casing 10 is an explosive propellant in the form of powder 12. The propellant 12 is ignited by means of a primer 14 which is actuated when struck by the firing pin of a firearm (not shown).

Held within neck 16 of casing 10 is a bismuth-containing bullet 18 according to one embodiment of the present invention. Bullet 18 shown in Fig. 1 is made in one piece with an all-metal continuous structure  
5 formed by any suitable method such as casting.

Applicant has discovered that bismuth is an excellent material for use in the manufacture of firearm bullets of any useful size. For example, the invention is applicable to bullets in the size range of  
10 from about .22 caliber up to 10 gauge slugs for shotguns. Fig. 2 shows a one-piece, bismuth-containing shotgun slug 19 according to one embodiment.

The present invention is also applicable to so-called "clad" or "jacketed" bullets, such as are  
15 illustrated in Figs. 3 and 4. These jacketed bullets include one or more bismuth-containing elements, each of which is formed as a one-piece element having a continuous all-metal structure primarily made up of bismuth.

20 In Fig. 3, the bullet 20 is made up of a single, one-piece, bismuth-containing core element 32 surrounded by a metal jacket 24, which can be of any suitable metal such as copper or copper alloy.

25 In Fig. 4, the bullet 26 includes two bismuth-containing core elements 28 and 30 which are surrounded by metal jacket 32.

In preferred embodiments, the bismuth-containing elements of jacketed bullets such as are shown in Figs. 2 and 3 comprise at least about 50% by weight of the  
30 entire bullet, more preferably, at least about 75% by weight thereof.

The bismuth-containing elements of bullets in accordance with the present invention are formed by casting, spin molding, dropping, punching or in any

other suitable manner, and can be made from substantially pure bismuth. It has also been discovered that bismuth provides an excellent alloy component when combined with other non-toxic metals for forming non-toxic bullets. For example, in preferred embodiments, the bismuth-containing elements of bullets in accordance with the present invention contain at least about 50% bismuth by weight. In more preferred embodiments, the bismuth-containing elements contain at least about 60%, 70%, 80%, 90% or 95% by weight bismuth.

Bismuth-containing elements of bullets formed from alloy containing 60-95% by weight or more bismuth perform well ballistically, and with increasingly high proportions of bismuth, such bullets approach or attain the ballistic performance of corresponding lead bullets.

In particularly preferred embodiments, the bismuth-containing elements of bullets according to the invention contain about 98% by weight or more bismuth. For example, an alloy containing about 98% by weight bismuth and about 2% by weight tin or antimony can be used in bullets which perform ballistically substantially the same as lead.

In other particularly preferred embodiments, the bismuth-containing elements of bullets in accordance with the present invention contain about 99% by weight or more bismuth. For example, an alloy of about 99% by weight bismuth and about 1% by weight zinc has about the same density as lead and performs substantially the same ballistically as lead.

The present invention can provide bullets which perform ballistically substantially the same as corresponding bullets made with lead. Furthermore,

bullets containing bismuth in accordance with the present invention have deformation characteristics similar to corresponding bullets made with lead. This provides bullets containing bismuth according to the invention with similar animal stopping characteristics as corresponding bullets made with lead, but without the poisonous effects of lead on the environment.

Since many modifications, variations and changes in detail may be made to the described embodiments, it is intended that all matter in the foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

CLAIMS:

1. A projectile comprising a lead-free firearm bullet, at least a principal portion of said bullet being formed of a one-piece element having a continuous all-metal structure primarily made up of bismuth, said bullet being of a size in the range of from about .22 caliber to about 10 gauge.
2. The projectile of Claim 1, wherein said one-piece element is formed of an alloy having substantially the same density as lead.
3. The projectile of Claim 1, wherein said one-piece element further comprises tin, antimony, zinc or a mixture thereof.
4. A projectile comprising a lead-free firearm bullet, at least a principal portion of said bullet being formed of a one-piece element having a continuous all-metal structure primarily made up of Bismuth, said one-piece element being formed by casting, spin molding, dropping or punching, said bullet being of a size in the range of from about .22 caliber to about 10 gauge.
5. The projectile of Claim 1, wherein said one-piece element contains at least about 50% by weight or more bismuth.
6. The projectile of Claim 1, wherein said one-piece element contains at least about 60% by weight or more bismuth.
7. The projectile of Claim 1, wherein said one-piece element contains at least about 70% by weight or more bismuth.

8. The projectile of Claim 1, wherein said one-piece element contains at least about 80% by weight or more bismuth.

5 9. The projectile of Claim 1, wherein said one-piece element contains at least about 90% by weight or more bismuth.

10 10. The projectile of Claim 1, wherein said one-piece element contains at least about 95% by weight or more bismuth.

11. The projectile of Claim 1, wherein said one-piece element contains at least about 98% by weight or more bismuth.

15 12. The projectile of Claim 1, wherein said one-piece element contains at least about 99% by weight or more bismuth.

13. The projectile of Claim 1, wherein said one-piece element contains at least about 50% by weight of said bullet.

20 14. The projectile of Claim 13, wherein said one-piece element is a bullet core, which bullet core is surrounded by a metal jacket.

15. The projectile of Claim 14, wherein said bullet core comprises at least about 75% by weight of said bullet.

25 16. The projectile of Claim 15, wherein said one-piece jacket contains copper.

30 17. The projectile of Claim 14, further including a second one-piece element having a continuous all-metal structure primarily made up of bismuth, the second one-piece element being a second bullet core which is surrounded by said metal jacket.

18. The projectile of Claim 17, wherein the first and second one-piece elements comprise at least about 75% by weight of said bullet.

5 19. The projectile of Claim 17, wherein said one-piece jacket contains copper.

20. The projectile of Claim 1, wherein said one-piece bullet is made up substantially entirely of said one-piece element having a continuous structure.

10 21. A firearm cartridge comprising:  
(a) a casing;  
(b) a propellant contained within said casing;  
(c) means for igniting said propellant; and  
15 (d) a lead-free firearm bullet, at least a principal portion of said bullet being formed of a one-piece element having a continuous all-metal structure primarily made up of bismuth.

20 22. The firearm cartridge of Claim 16, wherein said one-piece element provides said bullet with substantially the same density as a corresponding lead element.

## AMENDED CLAIMS

[received by the International Bureau  
on 27 March 1992 (27.03.92);

original claims 1,4,17 and 21 amended; other claims unchanged (3 pages)]

1. A projectile comprising a lead-free firearm  
bullet, at least a principal portion of said bullet  
being formed of a one-piece element having a continuous  
5 all-metal structure primarily made up of bismuth alloy,  
said bullet being of a size in the range of from about  
.22 caliber to about 10 gauge.

2. The projectile of Claim 1, wherein said one-  
piece element is formed of an alloy having  
10 substantially the same density as lead.

3. The projectile of Claim 1, wherein said one-  
piece element further comprises tin, antimony, zinc or  
a mixture thereof.

4. A projectile comprising a lead-free firearm  
15 bullet, at least a principal portion of said bullet  
being formed of a one-piece element having a continuous  
all-metal structure primarily made up of Bismuth alloy,  
said one-piece element being formed by casting, spin  
molding, dropping or punching, said bullet being of a  
20 size in the range of from about .22 caliber to about 10  
gauge.

5. The projectile of Claim 1, wherein said one-  
piece element contains at least about 50% by weight or  
more bismuth.

25 6. The projectile of Claim 1, wherein said one-  
piece element contains at least about 60% by weight or  
more bismuth.

7. The projectile of Claim 1, wherein said one-  
piece element contains at least about 70% by weight or  
30 more bismuth.

8. The projectile of Claim 1, wherein said one-piece element contains at least about 80% by weight or more bismuth.

5 9. The projectile of Claim 1, wherein said one-piece element contains at least about 90% by weight or more bismuth.

10 10. The projectile of Claim 1, wherein said one-piece element contains at least about 95% by weight or more bismuth.

11. The projectile of Claim 1, wherein said one-piece element contains at least about 98% by weight or more bismuth.

12. The projectile of Claim 1, wherein said one-piece element contains at least about 99% by weight or more bismuth.

13. The projectile of Claim 1, wherein said one-piece element contains at least about 50% by weight of said bullet.

14. The projectile of Claim 13, wherein said one-piece element is a bullet core, which bullet core is surrounded by a metal jacket.

15. The projectile of Claim 14, wherein said bullet core comprises at least about 75% by weight of said bullet.

16. The projectile of Claim 15, wherein said one-piece jacket contains copper.

17. The projectile of Claim 14, further including a second one-piece element having a continuous all-metal structure primarily made up of bismuth alloy, the second one-piece element being a second bullet core which is surrounded by said metal jacket.

18. The projectile of Claim 17, wherein the first and second one-piece elements comprise at least about 75% by weight of said bullet.

5 19. The projectile of Claim 17, wherein said one-piece jacket contains copper.

20. The projectile of Claim 1, wherein said one-piece bullet is made up substantially entirely of said one-piece element having a continuous structure.

10 21. A firearm cartridge comprising:  
(a) a casing;  
(b) a propellant contained within said casing;  
(c) means for igniting said propellant; and  
15 (d) a lead-free firearm bullet, at least a principal portion of said bullet being formed of a one-piece element having a continuous all-metal structure primarily made up of bismuth alloy.

20 22. The firearm cartridge of Claim 16, wherein said one-piece element provides said bullet with substantially the same density as a corresponding lead element.

## STATEMENT UNDER ARTICLE 19

In Claim 1, the all-metal structure is now defined as bismuth "alloy".

In Claim 4, the all-metal structure is now defined as Bismuth "alloy".

In Claim 17, the all-metal structure is now defined as bismuth "alloy".

In Claim 21, the all-metal structure is now defined as bismuth "alloy".

1/1

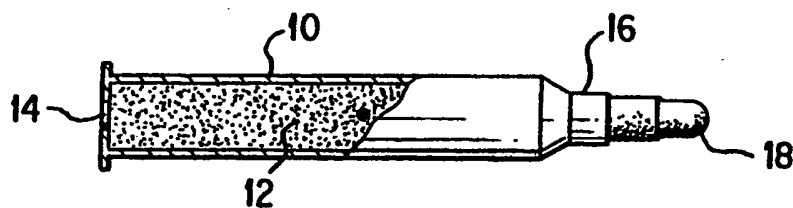


FIG. 1

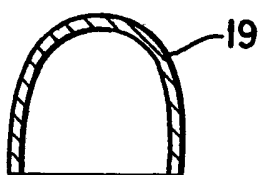


FIG. 2

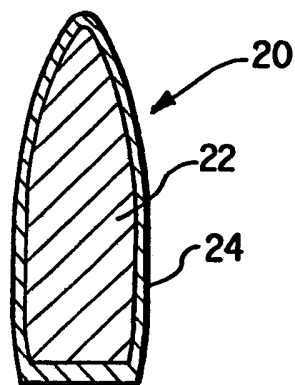


FIG. 3

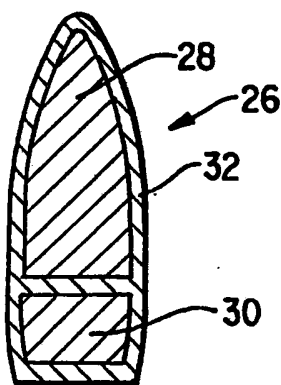


FIG. 4

## INTERNATIONAL SEARCH REPORT

International Application No

PCT/CA 91/00373

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 F42B12/74; C22C12/00		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	F42B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
Y	GB,A,2 121 522 (ROSE B.) 21 December 1983 see page 1, left column, line 5 - line 36; figure 2 see claims 1,8,9	1-22
Y	US,A,4 949 644 (BROWN J.) 21 August 1990 see the whole document	1-22
Y	GB,A,278 448 (OLIN J.) 23 November 1927 see page 2, line 54 - line 65; figure 9 see page 3, line 30 - line 45	14,15,16
Y	US,A,2 958 287 (AUXIER J.) 1 November 1960 see column 2, line 22 - line 28; figures 1-11 see column 3, line 12 - line 35	14,17-19
A	FR,A,2 609 540 (MESSAC E.) 15 July 1988	
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
20 DECEMBER 1991	29. 01. 92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	VAN DER PLAS J. <i>Van der Plas</i>	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO. CA 9100373  
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-2121522	21-12-83	None	
US-A-4949644	21-08-90	AU-A- 5836890 WO-A- 9100491	17-01-91 10-01-91
GB-A-278448		None	
US-A-2958287		None	
FR-A-2609540	15-07-88	None	

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